

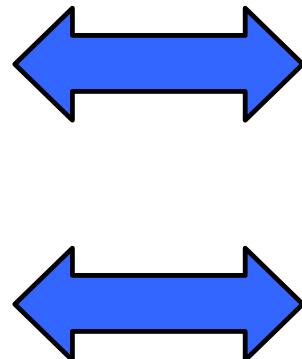
Unsteady Aerodynamics Experiment Wind Tunnel Testing and Data Acquisition

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Overview and Relevance

- UAE Tunnel Data**
- **Blade response**
 - Aerodynamic
 - Structural
 - **Wake dynamics**



- Turbine Furling**
- **Disk response**
 - Forces
 - Moments
 - **Tail vane dynamics**

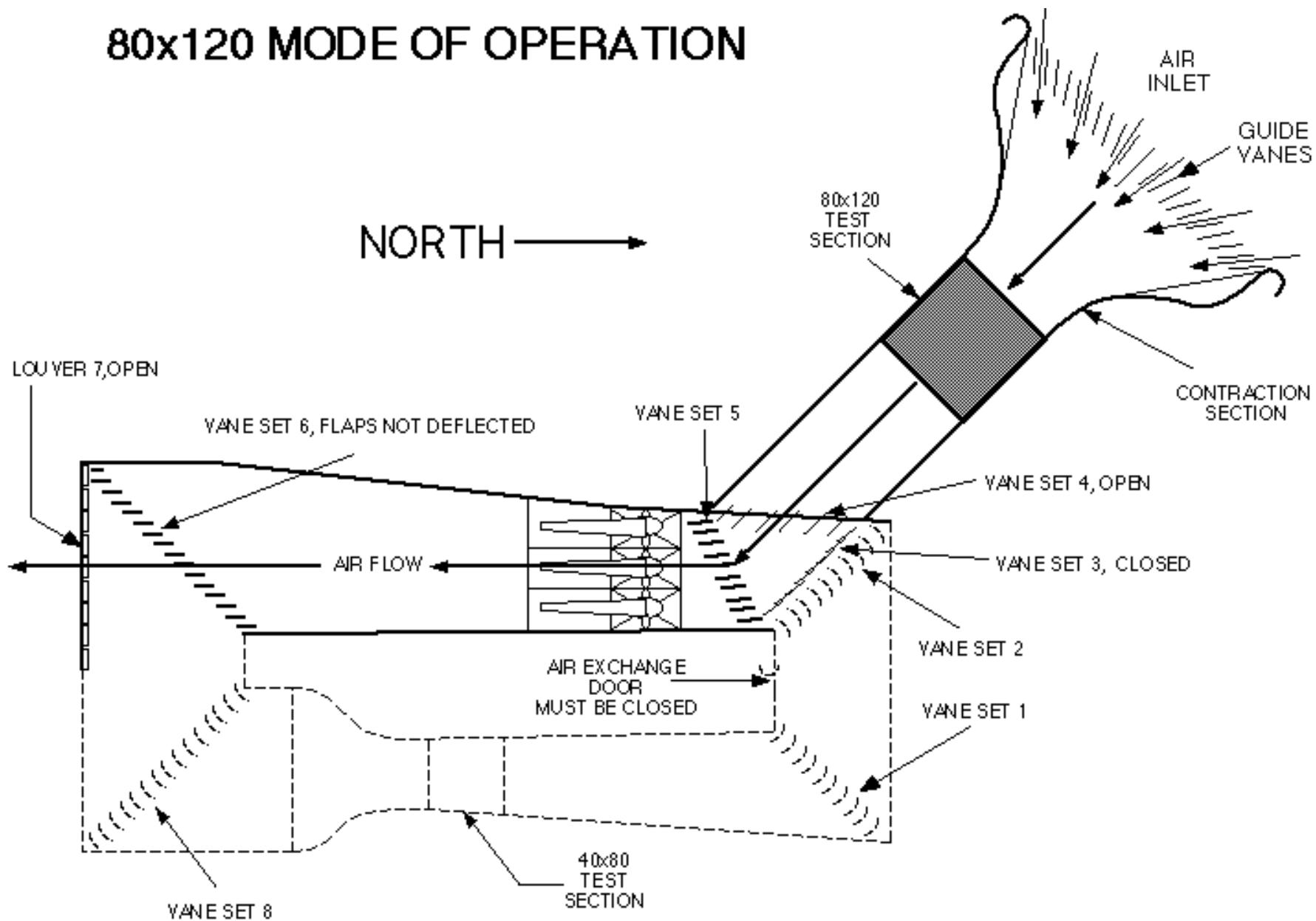
Unsteady Aerodynamics Experiment History

- Concept Validation
 - Blade surface pressure data (1987)
- Combined Experiment Rotor
 - Phases I,II: 3 untwisted blades
 - 58 5-minute data sets (1992)
- Unsteady Aerodynamics Experiment
 - Phase III: 3 twisted blades
 - 23 10-minute data sets (1995)
 - Phase IV: 3 twisted blades
 - 95 10-minute data sets (1996)
 - 75 10-minute data sets (1997)
 - Phase V: 2 twisted blades
 - 73 10-minute data sets (1998)
 - Phase VI: 2 twisted tapered blades
 - 26 10-minute data sets (1999)
- NASA Ames wind tunnel experiment



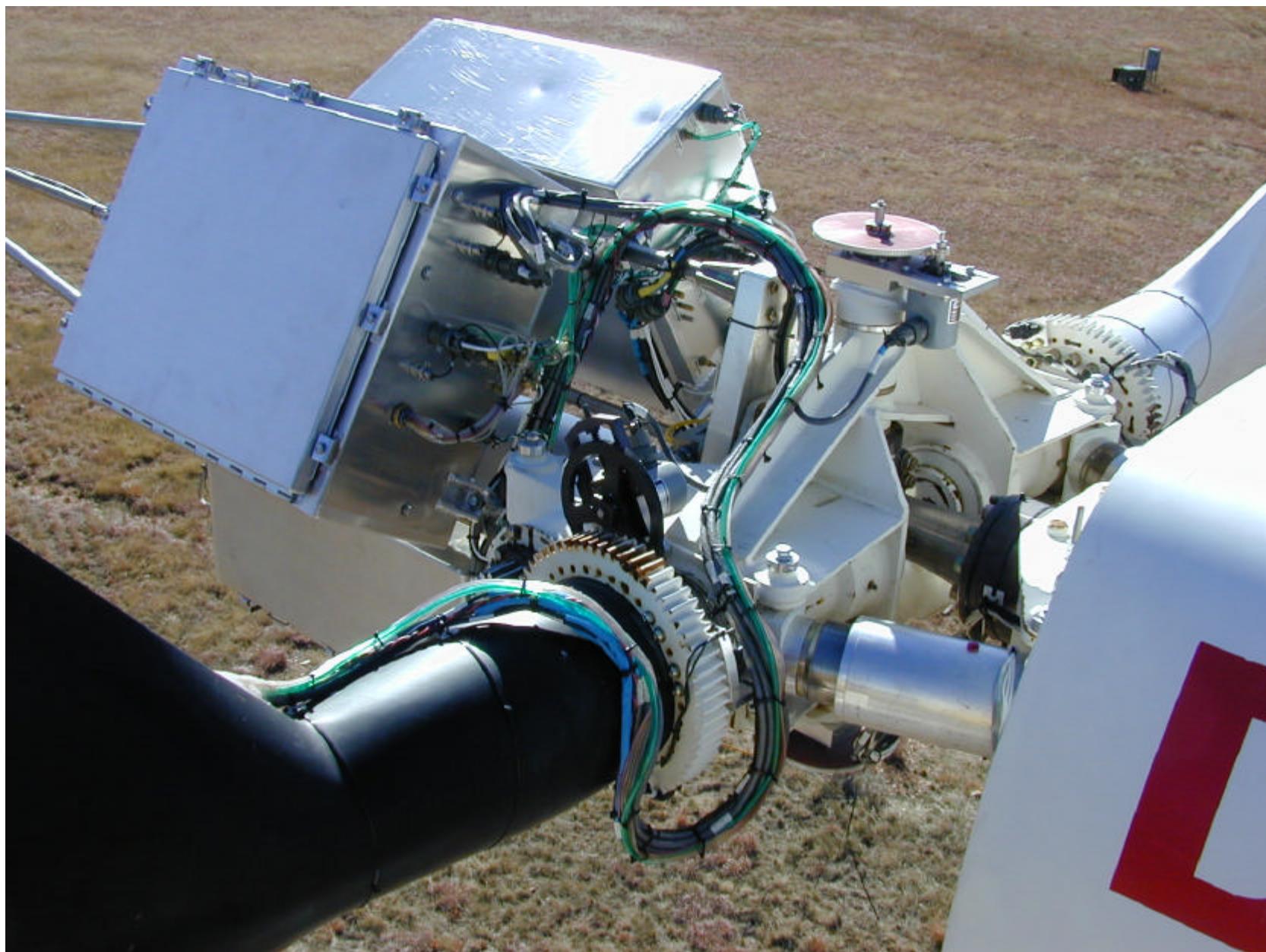


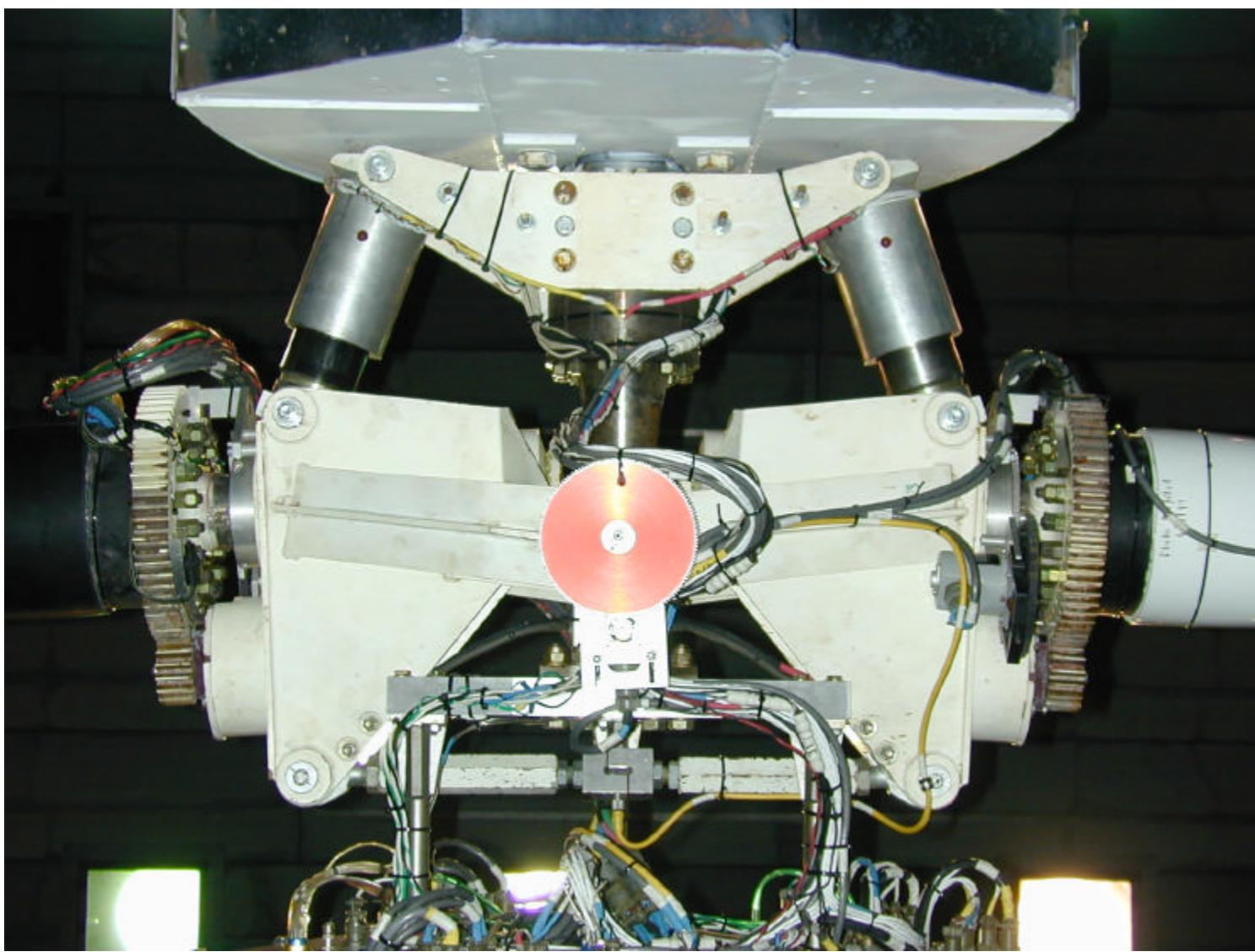
80x120 MODE OF OPERATION





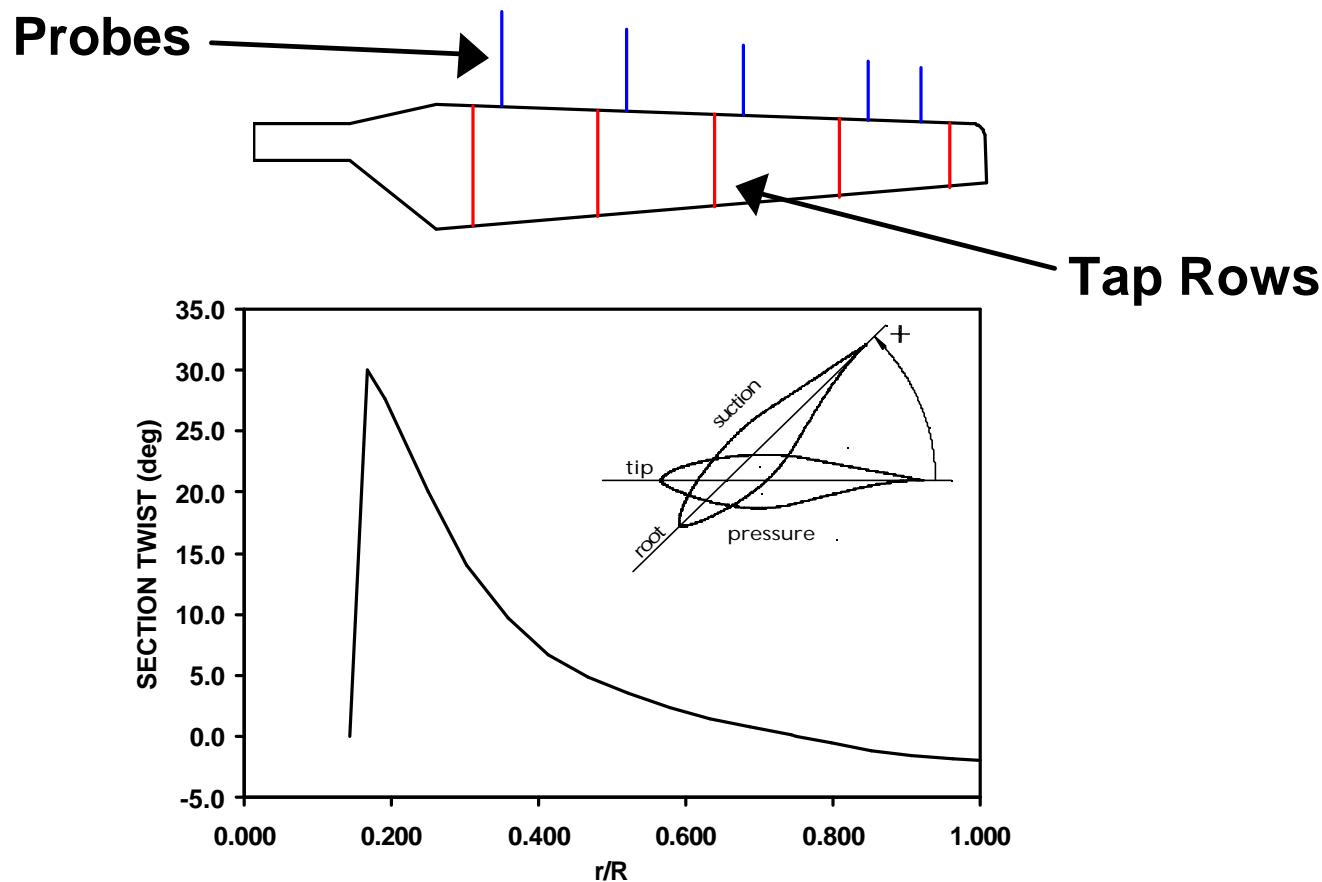






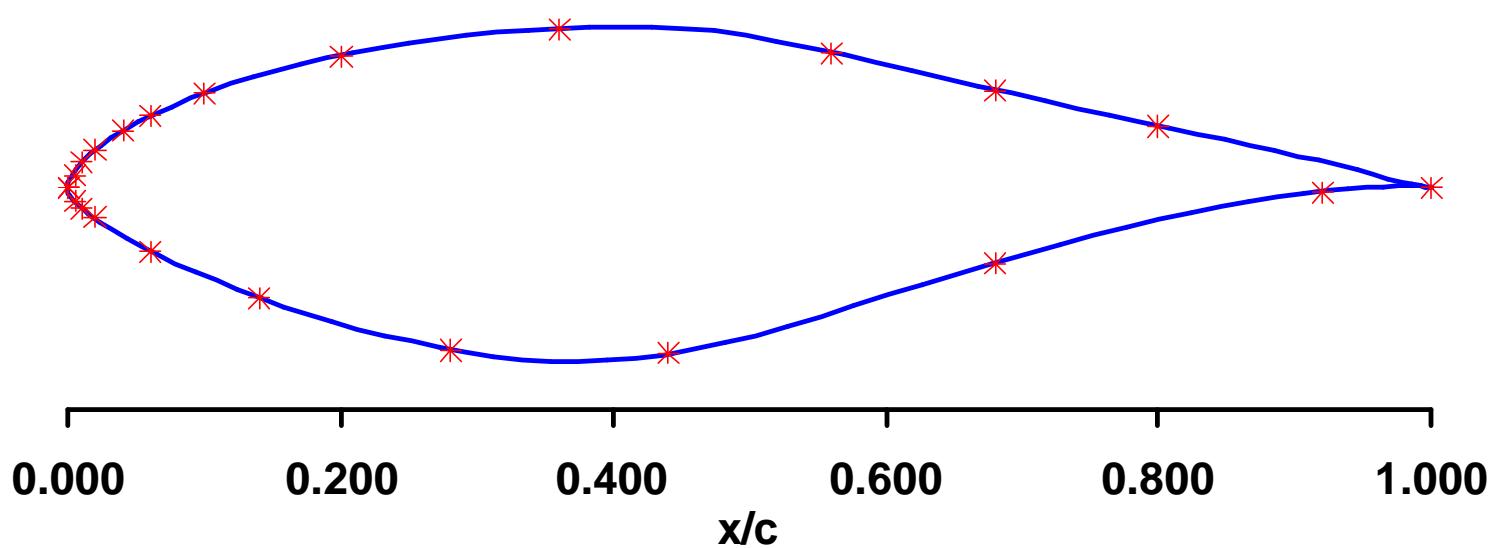
Planform Geometry

- $R = 5.03 \text{ m}$ for all but one test sequence
- Tap rows at $r/R = 0.30, 0.47, 0.63, 0.80, 0.95$
- Probes at $r/R = 0.34, 0.51, 0.67, 0.80, 0.91$



Airfoil Section Geometry

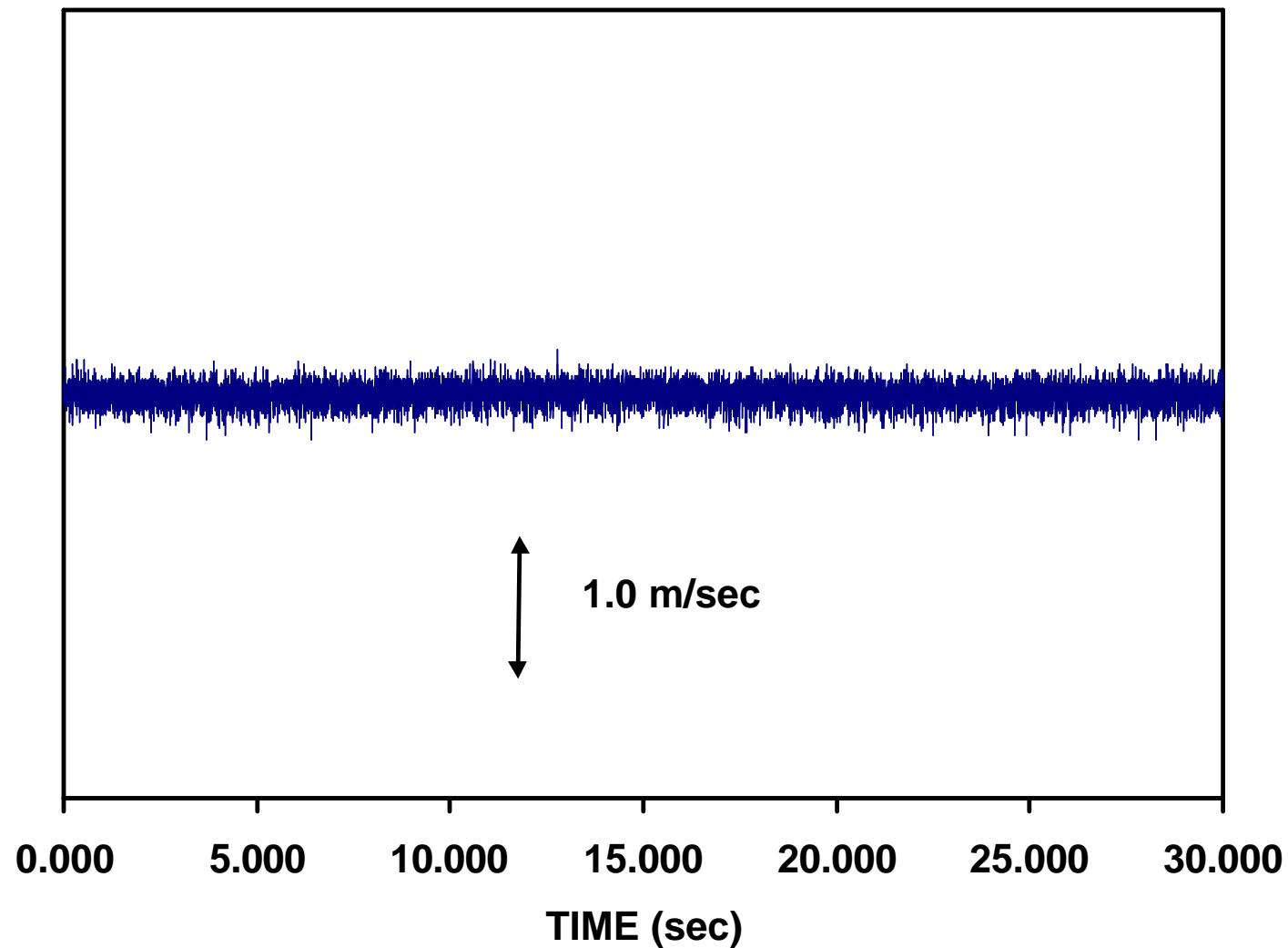
- S809 airfoil section
- Taps at LE and TE
- 11 upper surface taps
- 9 lower surface taps



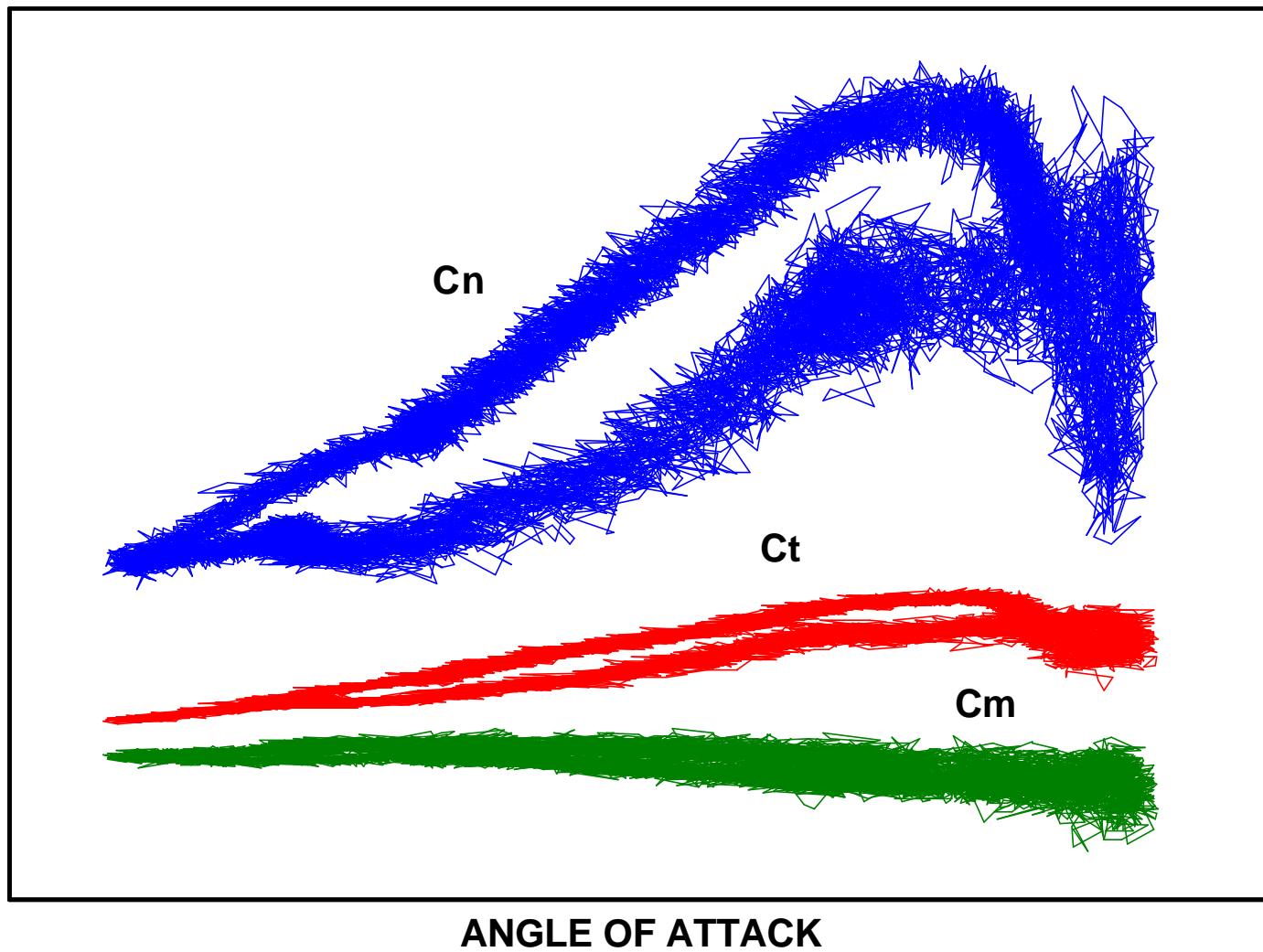
Test Configurations

- **Field operation**
 - Downwind baseline
 - Downwind high cone
 - Yaw releases
 - Downwind sonics
 - Upwind teetered
 - Upwind rigid
 - Upwind, no probes
 - Tip plate
 - Extended blade
 - Elevated RPM
- **Flow physics**
 - Transition fixed
 - Step pitch, parked
 - Step pitch, rotating
 - Sinusoidal pitch, parked
 - Sinusoidal pitch, rotating
 - Wake flow visualization
 - Dynamic inflow
 - Tower wake

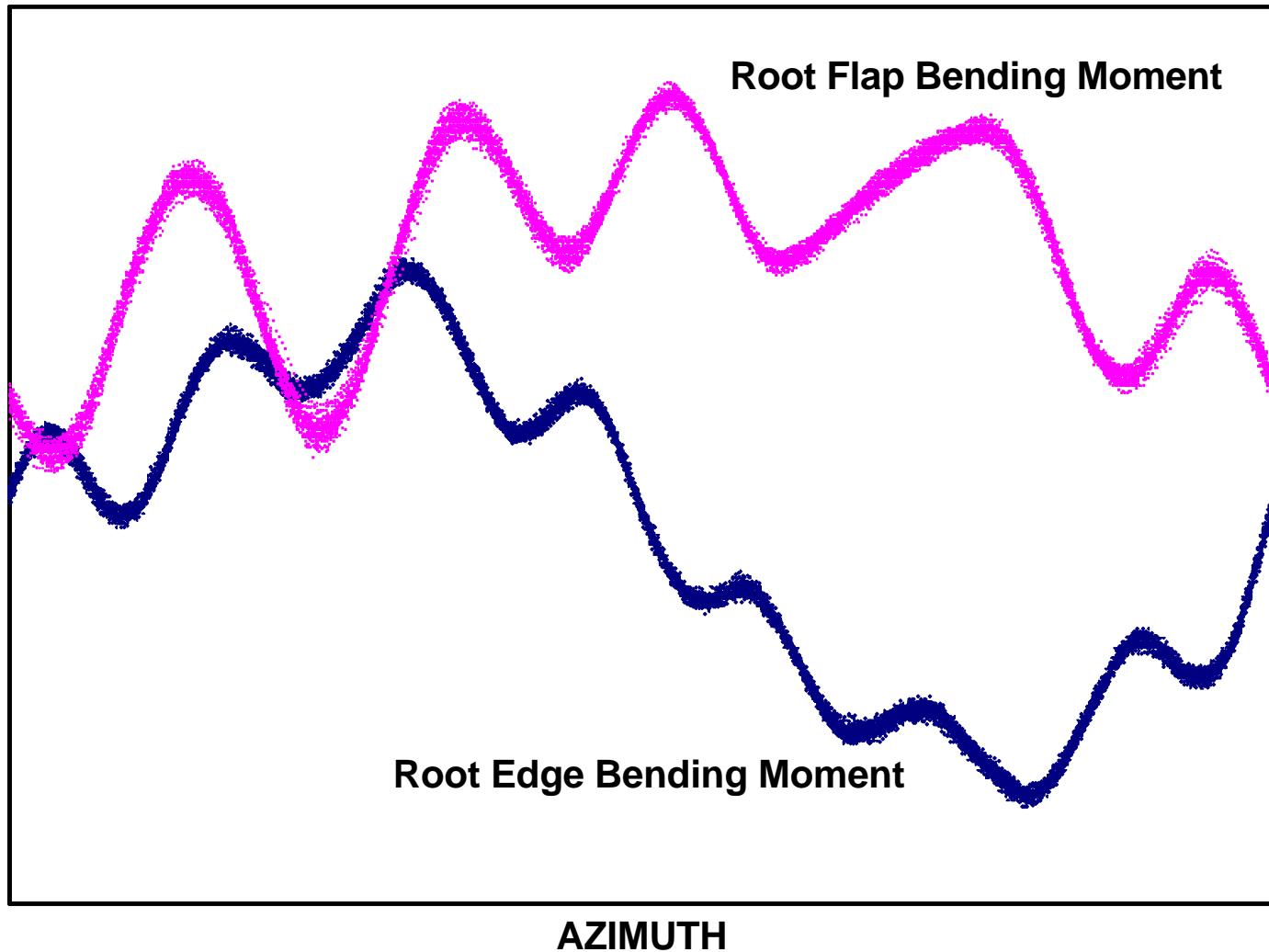
Typical Inflow Speed History



Typical Blade Aerodynamic Response



Typical Blade Structural Response



Electronic Data Channels

- Pressure
 - Surface (130)
 - Probe (25)
- Loads
 - Blade root flap and edge bending (4)
 - Teeter damper and link forces (3)
 - Low speed shaft bending and torque (2)
 - Nacelle yaw moment (1)
 - Wind tunnel balance (7)
- Accelerometers
 - Blade tip flap and edge (4)
 - Nacelle (3)
- Other
 - Blade pitch, flap, azimuth
 - Nacelle and table yaw
 - Wind speed
 - Power, RPM, time, etc.
- 213 Channels, 520.8 Hz sample rate

Wake Flow Visualization



Modified blade tip with
smoke generator installed

Wake flow visualization at
zero yaw, low wind speed



Data Release Considerations

- **Data quality assurance**
 - Processing software
 - Physical consistency
- **Code validation**
 - Blind comparison
 - Science Panel Meeting
- **Data release**
 - Broad dissemination
 - Straightforward access
- **Future plans**